HYDROLOGY

PRECIPITATION

The average annual precipitation in the Missouri portion of the watershed ranges from 40 to 44 inches. This is the second highest region of precipitation in the state, lead only by the Southeast Lowlands. The average annual watershed rainfall ranges from 12 to 16 inches, and average annual evaporation is 55 to 60 inches. Most rainfall occurs during the months of March, April, and May, and the driest period is December, January, and February. The average maximum rainfall for a 24-hour period is 2.5 to 3 inches expected every two years and 5 to 6 inches for a 24-hour period expected once every 25 years (MDNR 1986a).

GAGING STATIONS

The United States Geological Survey (USGS) has maintained gaging and water quality stations throughout the watershed since the early 1900s (Table HY01, Figure HY01). There are six active and three inactive gage stations located in the Missouri portion of the watershed and nine active and twenty-one inactive gage stations in the Arkansas portion of the watershed. Specific information from each station, for the period of record, can be found in annual Water Resources Data Reports published by the USGS in Rolla, MO and Little Rock, AR.

PERMANENT AND INTERMITTENT STREAMS

There are many streams in the watershed which are considered intermittent for all or part of their

length. The total mileage for intermittent streams with permanent pools is 210.5 miles for the Missouri portion of the watershed. The length of streams with permanent flow is 298.5 miles (Funk 1968). Intermittent streams are represented as broken blue lines on USGS 7.5 minute topographic maps, while permanent streams are represented with solid blue lines. Figure HY02 shows coverage of USGS 7.5 minute topographic maps for the watershed, and map names are listed in Table HY02.

Losing stream reaches, streams that lose portions or all of their surface flow to underground flow, are listed in Table HY03 for the Missouri portion of the watershed. Losing streams are direct links between surface water and groundwater and have the potential to transfer undesirable contaminants to groundwater.

Base flows in most streams are well sustained during dry weather, due in part to the high storage capacity of the regional geology, coupled with favorable precipitation and runoff conditions. Springs help sustain flow in many watershed streams. There were 104 watershed springs identified from USGS 7.5 minute topographic maps. Springs in the watershed are listed in Table GE01and displayed in Figure GE02. The largest spring in the Missouri portion of the watershed, for which flow has been determined, is Roaring River Spring, with an average daily flow of 20,400,000 gallons and a maximum recorded daily flow of 114,000,000 gallons (Vineyard 1982).

STREAM FLOW

Instream flow refers to the quantity of water, and its variation over time, as it exists in a watercourse, also referred to as flow regime. Some instream flow uses in the watershed include, protection of aquatic organisms, hydroelectric power production, recreation, channel maintenance, and transport of effluent discharges.

The 7-day Q^2 and Q^{10} values represent the relative permanence of a stream. The 7-day low flow discharges, with recurrence intervals of two years (Q^2) and ten years (Q^{10}), for locations throughout the watershed are found in Table HY04. The minimum recorded flow from Beaver Dam is 47 cubic feet per second (cfs) and from Table Rock Dam is 100 to 110 cfs (MDNR 1996b). Table HY05 gives historic high and low flow information for several gage stations throughout the watershed. Base flows are maintained by springs and, even during the driest periods, watershed streams have some of the best maintained base flows in Missouri. The high relief of the watershed results in rapid runoff during periods of heavy rain, and stream levels can increase rapidly.

DAMS AND HYDROPOWER INFLUENCES

There are three large hydroelectric dams on the mainstem White River; Beaver Dam, Table Rock Dam, and Bull Shoals Dam. All three are owned by the USCOE and electricity is distributed by the Southwestern Power Administration (SWPA). The dams were constructed and are operated for flood control and to provide electric power, with an added authorization of Bull Shoals Lake

to provide water for municipal and industrial uses. Much discussion has taken place concerning a reauthorization of the White River Reservoir System to include recreation and natural resources in the stated purposes of the lakes. Powersite Dam is a considerably smaller mainstem hydroelectric dam owned and operated by the Empire District Electric Company (EDEC).

The uppermost mainstem hydroelectric dam is Beaver Dam near Eureka Springs, AR at river mile (RM) 609.0. Beaver Lake was formed in 1963 with the closing of Beaver Dam. Beaver Lake has a conservation pool elevation of 1,120 feet above mean sea level (msl) and a flood pool elevation of 1,135 msl. Beaver Lake contains 28,220 surface acres of water at conservation pool and 31,700 acres of surface water at flood pool. Beaver Lake impounds 37 miles of the White River.

The first mainstem hydroelectric dam in the Missouri portion of the watershed, and second in line below Beaver Dam, is Table Rock Dam near Branson, MO, located at RM 528.8. Table Rock Dam was closed in June of 1959, and Table Rock Lake impounds approximately 80 miles of the mainstem White River. Table Rock Lake's conservation pool elevation is 915 feet msl, and the flood pool elevation is 931 feet msl. Table Rock Lake, at conservation pool, has 39,652 surface acres in Missouri and 3,448 surface acres in Arkansas. Table Rock Lake at full flood pool impounds water to within about 3 miles of Beaver Dam.

The next mainstem dam is Powersite Dam located at RM 506.1. Powersite Dam is a considerably smaller mainstem hydroelectric dam owned and operated by EDEC. Powersite Dam was closed in 1913 creating 2,080-acre, Lake Taneycomo. Lake Taneycomo impounds 22 miles of the White River, and the top of the overflow dam has an elevation of 701.2 feet msl. Water releases from Table Rock Dam vary hourly and daily and keep Lake Taneycomo in a somewhat riverine state.

Bull Shoals Dam is the next in the series of mainstem hydroelectric dams, located near Mountain Home, AR. Bull Shoals Dam was closed in 1952 impounding 86 miles of the White River and creating Bull Shoals Lake. Bull Shoals Dam is located at RM 418.6. Bull Shoals has a conservation pool elevation of 654 feet msl and flood control elevation of 695 feet msl. Bull Shoals Lake at conservation pool covers 16,335 surface acres in Missouri and 29,105 surface acres in Arkansas.

The most obvious impact these dams have had on the White River is the inundation of the total Missouri length of the mainstem White River and the loss of habitat and aquatic fauna associated with this type of riverine system. Reservoir construction has also had a negative impact on lower stretches of tributary streams by altering flow regimes and negatively impacting riparian vegetation and aquatic life. Specific examples of species losses attributed to reservoir construction are dealt with in the biotic section.

Cold water releases from the three large mainstem dams have drastically altered the warmwater fisheries that once existed in the mainstem White River. The water released from the hypolimnion of the reservoirs is colder than that which once sustained the native fishery. These temperature changes have had the most noticeable impact in stream reaches closest to the dams, but less

obvious impacts have been observed through the entire White River system, to its confluence with the Mississippi River (Shirley 1992).

Directly below each of the three major dams, coldwater fish species have been introduced and now replace the native warmwater species. Congress authorized the building of the Norfork National Fish Hatchery in 1956 as partial mitigation for the lost warmwater fishery (Patterson 1993). As a result, trout have been stocked in the tailwaters of the three dams and a put-and-take trout fishery has existed since that time. A study conducted on Lake Taneycomo compared fish populations between the pre-Table Rock warmwater conditions and the post-Table Rock coldwater conditions (Table HY06). Lake Taneycomo as a warmwater fishery had standing stocks that included largemouth bass (8.7%), crappie (4.6%), other sunfishes (13.2%), and catfishes (9.7%) (percents indicate species percent of total standing stock). At the time of the survey no trout were present. Within nine years of the impounding of Table Rock Lake and the ensuing coldwater release, trout made up 95% of the harvest in Lake Taneycomo (Shirley 1992).

Low dissolved oxygen levels in the tailwaters of the three major dams (Beaver, Table Rock, and Bull Shoals dams) has also had negative impacts on the introduced coldwater fisheries. Increased nutrification from human and agricultural sources has spurred lower dissolved oxygen levels in the hypolimnion of the reservoirs (USGS 1995). The dams are all bottom release structures, and low oxygen levels in the tailwaters have caused problems for the introduced fishes which are very sensitive to low dissolved oxygen levels. The greatest potential for low dissolved oxygen problems occurs from July through December as the lakes stratify into distinct layers. A cooperative effort between SWPA, USCOE, EDEC, AG&FC and MDC has tried several methods to improve dissolved oxygen levels below the three large dams.

Instream flow, affected by the four mainstem dams, is a major issue in the watershed. Instream flow affects the availability of aquatic habitat, dissolved oxygen levels, and angling opportunities. Operation of Beaver and Bull Shoals dams, in Arkansas, and Table Rock Dam in Missouri substantially alter stream flows in the White River system. Hydroelectric peaking operation at these dams results in rapid changes in flow, extremely low flows, dewatered substrate, reduced fish and invertebrate habitat, and low tailwater dissolved oxygen levels, all of which can prove detrimental to fish and invertebrate populations. A study conducted by MDC (Lobb, Kruse, and Roell 1997) found that substantial increases in aquatic habitat in the tailwater section of Lake Taneycomo, directly below Table Rock Lake, would result from moderate increases in the normal flow release of Table Rock Dam. Recommendations for improving stream flow management at Table Rock Dam have been forwarded to the USCOE. Additional research is needed to refine these recommendations and fully document the benefits to the aquatic community and the Lake Taneycomo recreational fishery. Similar efforts to study and improve stream flow management at Bull Shoals are further along for the Arkansas portion of the White River. Further interstate efforts to establish minimum flows below these dams are ongoing, and cooperation between MDC, AG&FC, USCOE and SWPA remains critical to finding better ways to manage flows and protect the downstream fisheries (Lobb D., MDC memo, 1998).

Table HY01. United States Geological Survey (USGS) gage stations in the White River watershed.

Gage Number	Gage Name	Status*	Drainage Area (m^2)	Type **	Location T R S
07050150	Roaring River Spring near Cassville	A		WQ	22N 27W 11
07050152	Roaring River at Roaring River State Park	I		WQ	22N 27W 34
07053400	Table Rock Lake near Branson	A	4,020	WQ	22N 22W 22
07053450	White River Below Table Rock Dam	A		WQ	22N 22W 11
07053500	White River near Branson	I	4,022	WS	22N 22W 22
07053600	Lake Taneycomo at College of the Ozarks	A		WQ	22N 21W 04
07053700	Lake Taneycomo at Branson	I		WQ	22N 21W 04
07053810	Bull Creek near Walnut Shade	A	191	WS	23N 21W 04
07054080	Beaver Creek at Bradleyville	A	298	WS	24N 18W 11
07048550	West Fork of White River east of Fayettville	I	118	WQ	16N 30W 24
07048700	White River near Goshen	I	412	WQ	17N 28W 31
07049691	White River at Beaver Dam	I	1,192	WQ	20N 27W 10
07050390	Osage Creek southwest of Berryville	I		WQ	20N 25W 36
07050420	Osage Creek west of Berryville	I		WQ	20N 25W 26
07050500	Kings River near Berryville	A	527	Both	20N 25W 03
07053230	Long Creek near Denver	I		WQ	21N 22W 34
07053207	Long Creek at Denver	A	104	WS	21N 22W 34
07054501	White River at Bull Shoals Dam	A	6,051	WQ	20N 15W 21
07055565	Crooked Creek at Harrison	I	67	WQ	18N 20W 03
07055569	Crooked Creek near Harrison	I		WQ	18N 20W 02

Gage Number	Gage Name	Status*	Drainage Area (m^2)	Type **	Location T R S
07055608	Crooked Creek at Yellville	A	406	Both	18N 16W 09
07048000	West Fork White River at Greenland	I	83.1	Both	18N 30W 16
07048500	West Fork White River near Fayetteville	I	118	WS	16N 30W 24
07048600	White River near Fayetteville	A	400	Both	16N 29W 08
07049000	War Eagle Creek near Hindsville	A	263	WS	18N 27W 28
07049695	White River above Busch	I	1,192	WQ	21N 27W 34
07050000	White River at Beaver	I	1,244	WQ	21N 26W 20
07054535	Whiter River below Bruce Creek near Lakeview	I		WQ	19N 15W 35
07055000	White River near Flippin	I	6,081	WS	19N 15W 10
07055550	Crooked Creek Tributary near Dog Patch	I	4	WQ	17N 20W 04
07055600	Crooked Creek at Pyatt	I	207	WQ	19N 17W 31
07054410	Bear Creek near Omaha	A	133	WS	21N 20W 26
07053250	Yocum Creek near Oak Grove	A	53	WS	21N 22W 30
07048800	Richland Creek at Goshen	A	138	WS	17N 28W 31

*Status A= active, I= inactive

**Type WQ= water quality, WS= water stage, Both= water stage and water quality.

Source: (Wilson, G. and Porter, E., USGS, pers. comm.)

Table HY02. USGS 7.5 minute topographic map coverage of the White River watershed.

Quad #	Quad Name	Quad #	Quad Name
	MISSOURI TOPOGRAPHIC MAPS		
689	Seligman	754	Protem NE
690	Eagle Rock	755	Thornfield
691	Golden	756	Wilhoit
692	Viola	757	Gainesville NW
693	Lampe	806	Spokane
694	Table Rock Dam	807	Day
695	Hollister	808	Garrison
696	Mincy	809	Bradleyville
697	Protem SW	810	Brown Branch
698	Protem	811	Smallet
699	Theodosia	812	Wasola
700	Isabella	862	Highlandville
701	Gainesville	863	Selmore
745	Exeter	864	Chadwick
746	Cassville	865	Keltner
747	Shell Knob	866	Goodhope
748	Cape Fair	867	Ava
749	Reeds Springs	920	Rogersville
750	Garber	921	Bruner
751	Branson	922	Dogwood
752	Forsyth	923	Cedar Gap
753	Hilda		
	ARKANSAS TOPOGRAPHIC MAPS		
656	Bidville	818	Gaither
657	Cass	819	Harrison
693	Winslow	820	Everton
694	Brentwood	821	Bruno
695	Delaney	822	Yellville
696	St. Paul	823	Rea Valley
697	Pettigrew	824	Buffalo City
698	Boston	846	Bentonville South

Quad #	Quad Name	Quad #	Quad Name
	ARKANSAS TOPOGRAPHIC MAPS (continued)		
732	Prairie Grove	847	Rogers
733	West Fork	848	War Eagle
734	Sulphur City	849	Sandstone Moutain
735	Durham	850	Rockhouse
736	Japton	851	Berryville
737	Witter	852	Green Forest
738	Weathers	853	Alpena
739	Boxley	854	Batavia
773	Fayetteville	855	Bergman
774	Elkins	856	Zinc
775	Goshen	857	Pyatt
776	Hartwell	858	Cotter SW
777	Huntsville	859	Cotter
778	Kingston	860	Mountain Home West
779	Osage SW	884	Pea Ridge
780	Ponca	885	Garfield
781	Jasper	886	Beaver
782	Hasty	887	Eureka Springs
783	Western Grove	888	Grandview
784	St. Joe	889	Blue Eye
810	Springdale	890	Denver
811	Sonora	891	Omaha
812	Spring Valley	892	Omaha NE
813	Hindsville	893	Diamond City
814	Forum	894	Bentonville South
815	Marble	895	Cotter NW
816	Osage	896	Bull Shoals
817	Osage NE	897	Midway

Table HY03. Losing streams in the Missouri portion of the White River watershed.

Stream Name	County	Length (miles)	Start T R S	End T R S
Unnamed trib.to West Fk.Bull Creek	Christian	2.0	26N 20W 04	26N 20W 08
Unnamed trib. to Woods Fk. BullCr.	Christian	1.0	26N 21W27	26N 21W 33
Prairie Creek	Douglas	2.5	26N 16W 16	26N 16W 18
Unnamed trib. to Prairie Creek	Douglas	0.7	26N 16W 21	26N 16W 16
Unnamed trib. to Prairie Creek	Douglas	0.7	26N 16W 15	26N 16W 16
Unnamed trib. to Prairie Creek	Douglas	0.5	27N 15W 03	27N 15W 03
Unnamed trib. to Prairie Creek	Douglas	0.3	26N 16W 15	26N 16W 15
South Fork	Ozark	6.9	24N 14W 28	24N 15W 33
Thompson Hollow	Ozark	4.5	23N 15W 01	23N 15W 17
Turkey Creek	Ozark	11.0	24N 15W 02	23N 15W 17
Unnamed trib. to South Fork	Ozark	0.9	24N 14W 31	24N 15W 36
Unnamed trib. to South Fork	Ozark	0.7	24N 14W 32	24N 14W 31
Unnamed trib. to South Fork	Ozark	0.7	24N 14W 32	24N 14W 32
Unnamed trib. to South Fork	Ozark	0.4	24N 15W 24	24N 15W 25
Unnamed trib. to South Fork	Ozark	1.1	24N 15W 24	24N 15W 25
Unnamed trib. to South Fork	Ozark	0.7	24N 14W 19	24N 14W 30
Unnamed trib. to South Fork	Ozark	1.5	24N 14W 20	24N 14W 30
Unnamed trib. to South Fork	Ozark	1.2	24N 14W 20	24N 14W 30
Unnamed trib. to South Fork	Ozark	1.0	24N 14W 29	24N 14W 29
Unnamed trib. to South Fork	Ozark	0.5	24N 14W 29	24N 14W 29
Unnamed trib. to South Fork	Ozark	3.6	24N 14W 32	24N 15W 35
Unnamed trib. to South Fork	Ozark	3.5	24N 15W 13	24N 15W 34
Unnamed trib. to Turkey Creek	Ozark	3.0	24N 15W 01	24N 15W 15
Unnamed trib. to Turkey Creek	Ozark	0.7	24N 15W 10	24N 15W 10
Unnamed trib. to Turkey Creek	Ozark	0.8	24N 15W 09	24N 15W 15
Unnamed trib. to Turkey Creek	Ozark	0.7	24N 15W 16	24N 15W 15
Unnamed trib. to Turkey Creek	Ozark	1.0	24N 15W 16	24N 15W 22
Unnamed trib. to Turkey Creek	Ozark	0.5	24N 15W 21	24N 15W 22
Unnamed trib. to Turkey Creek	Ozark	1.0	24N 15W 28	24N 15W 33
Unnamed trib. to Turkey Creek	Ozark	0.8	24N 15W 28	24N 15W 33
Unnamed trib. to Turkey Creek	Ozark	1.0	24N 15W 32	23N 15W 04
Unnamed trib. to Turkey Creek	Ozark	0.6	24N 15W 32	24N 15W 32
Unnamed trib. to Turkey Creek	Ozark	0.2	24N 15W 02	24N 15W 02
Unnamed trib. to Turkey Creek	Ozark	1.4	24N 15W 11	24N 15W 14
Unnamed trib. to Turkey Creek	Ozark	0.7	24N 15W 12	24N 15W 11
Unnamed trib. to Turkey Creek	Ozark	1.1	24N 15W 12	24N 15W 14
Unnamed trib. to Turkey Creek	Ozark	0.7	24N 15W 14	24N 15W 15
Unnamed trib. to Turkey Creek	Ozark	0.8	24N 15W 23	24N 15W 22
Unnamed trib. to Turkey Creek	Ozark	0.8	24W 15N 22	24N 15W 27
Unnamed trib. to Turkey Creek	Ozark	1.4	23N 15W 03	23N 15W 08
Unnamed trib. to Turkey Creek	Ozark	0.9	23N 15W 04	23N 15W 09
Unnamed trib. to Table Rock Lake	Stone	1.0	23N 23W 26	23N 23W 34
Unnamed trib. to Table Rock Lake	Stone	1.9	23N 23W 13	22N 23W 30
Unnamed trib. to Table Rock Lake	Stone	1.1	23N 22W 20	23N 22W 19

Source: MDNR (1986a).

Table HY04. Seven-day low flow discharges in cubic feet per second (cfs) with recurrence intervals of two years (Q^2) and ten years (Q^{10}) for selected streams in the White River watershed.

Stream	Location	Period of Record	7-Day Q^2	7-Day Q^{10}
Roaring River	Cassville	1923-72	14	7
Swan Creek	Forsyth	1923-67	5	0.7
Beaver Creek	Bradleyville	1964-72	19	11
Little Beaver Creek	Bradleyville	1964-70	9	3.4

Source: MDNR (1996a).

Table HY05. Historic flow data for selected White River USGS gaging stations in cubic feet per second (cfs).

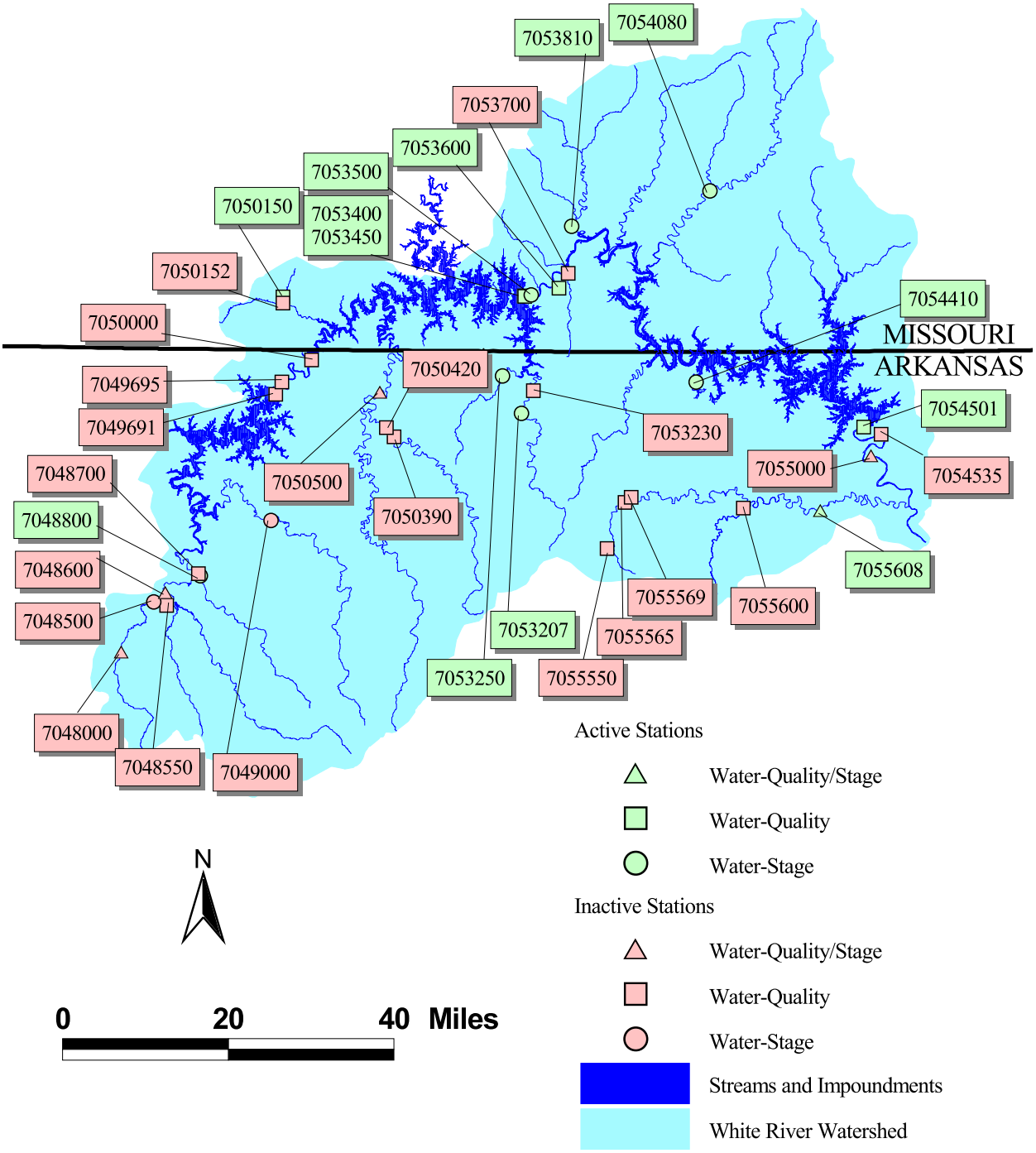
Gage Number	Water Years	Drainage Area (mi^2)	Annual Mean	Highest Annual Mean	Lowest Annual Mean	Highest Daily Mean	Lowest Daily Mean
07053500	1960-1996	4,022	3,967	7,161	852	33,000	40
07053810	1995-1996	191	212	330	95	6280	2
07054080	1995-1996	298	331	464	199	5900	24

Table HY06. Changes in the fishery of Lake Taneycomo resulting from cold water releases below Table Rock Dam.

Species	% of standing stock (1958 and 1959)	Annual sportfish yield (% by weight)									
		'60	'61	'62	'63	'64	'65	'66	'67	'68	'71
Black bass	8.7	8	4	3	4	2	3	2	3	1	2
Crappie	4.6	21	11	5	5	3	4	3	0	0	0
Other sunfish	13.2	3	2	5	9	1	2	2	4	2	3
Walleye	0.4	2	1	1	*	*	0	0	0	0	0
Catfish	9.7	5	3	1	2	1	1	2	3	0	*
Common carp	11.9	*	1	1	0	*	0	0	*	0	0
Rainbow trout	0	57	68	81	78	92	90	92	90	96	95

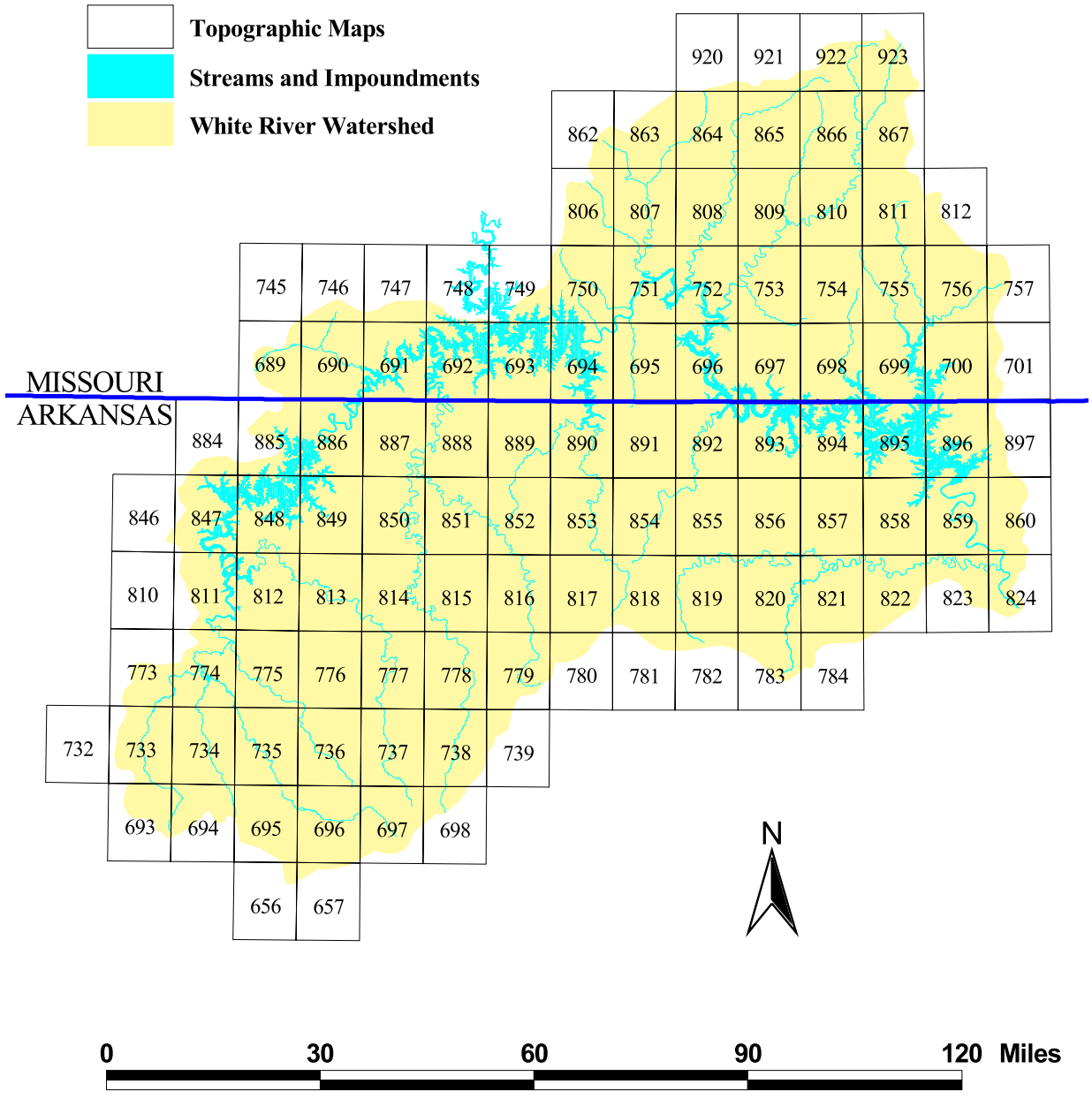
*Indicates less than 0.5% of catch.
Source: Shirley (1992).

Figure HY01. USGS gage stations in the White River watershed.



Note: USGS gage station numbers reference Table HY01.

Figure HY02. USGS 7.5 minute topographic map coverage for the White River watershed.



Note: Map numbers reference Table HY02.